ANNEX U

Sulfur Dioxide Emissions

Sulfur dioxide (SO_2), emitted into the atmosphere through natural and anthropogenic processes, affects the Earth's radiative budget through photochemical transformation into sulfate aerosols that can (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) affect cloud formation; and (3) affect atmospheric chemical composition (e.g., stratospheric ozone, by providing surfaces for heterogeneous chemical reactions). The overall effect of SO_2-derived aerosols on radiative forcing is believed to be negative (IPCC 1996). However, because SO_2 is short-lived and unevenly distributed through the atmosphere, its radiative forcing impacts are highly uncertain. Sulfur dioxide emissions have been provided below in Table U-1.

The major source of SO_2 emissions in the United States was the burning of sulfur containing fuels, mainly coal. Metal smelting and other industrial processes also released significant quantities of SO_2. The largest group of contributors to U.S. emissions of SO_2 was the electric utilities, accounting for 69 percent in 2001 (see Table U-2). Coal combustion accounted for approximately 92 percent of SO_2 emissions from electric utilities in the same year. The second largest source was industrial fuel combustion, which produced 14 percent of 2001 SO_2 emissions. Overall, SO_2 emissions in the United States decreased by 32 percent from 1990 to 2001. The majority of this decline came from reductions from electric utilities, primarily due to increased consumption of low sulfur coal from surface mines in western states.

Sulfur dioxide is important for reasons other than its effect on radiative forcing. It is a major contributor to the formation of urban smog and acid rain. As a contributor to urban smog, high concentrations of SO_2 can cause significant increases in acute and chronic respiratory diseases. In addition, once SO_2 is emitted, it is chemically transformed in the atmosphere and returns to earth as the primary contributor to acid deposition, or acid rain. Acid rain has been found to accelerate the decay of building materials and paints, and to cause the acidification of lakes and streams and damage trees. As a result of these harmful effects, the United States has regulated the emissions of SO_2 under the Clean Air Act. The EPA has also developed a strategy to control these emissions via four programs: (1) the National Ambient Air Quality Standards program,[1] (2) New Source Performance Standards,[2] (3) the New Source Review/Prevention of Significant Deterioration Program,[3] and (4) the sulfur dioxide allowance program.[4]

References

EPA (2003) Unpublished data provided by U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC.

Table U-1: SO_2 Emissions (Gg)

Sector/Source	1990	1995	1996	1997	1998	1999	2000	2001
Energy	**19,629**	**15,773**	**15,727**	**16,104**	**16,196**	**15,079**	**13,823**	**13,314**
Stationary Combustion	18,407	14,724	14,746	15,104	15,191	14,073	12,883	12,367
Mobile Combustion	793	673	649	659	665	701	632	636
Oil and Gas Activities	390	334	304	312	310	275	279	281
Waste Combustion	39	42	29	29	30	29	29	30
Industrial Processes	**1,306**	**1,117**	**953**	**985**	**991**	**933**	**977**	**1,008**
Chemical Manufacturing	269	260	231	235	237	284	295	298
Metals Processing	658	481	353	369	367	297	306	325
Storage and Transport	6	2	5	5	5	5	5	5
Other Industrial Processes	362	365	350	371	376	337	352	370
Miscellaneous*	11	9	14	5	5	11	19	9

[1] [42 U.S.C § 7409, CAA § 109]
[2] [42 U.S.C § 7411, CAA § 111]
[3] [42 U.S.C § 7473, CAA § 163]
[4] [42 U.S.C § 7651, CAA § 401]

Solvent Use	**+**		**1**	**1**	**1**	**1**	**1**	**1**	**1**
Degreasing	+		+	+	+	+	+	+	+
Graphic Arts	+		+	+	+	+	+	+	+
Dry Cleaning	NA		+	+	+	+	+	+	+
Surface Coating	+		+	+	+	+	+	+	+
Other Industrial	+		+	1	1	1	1	1	1
Non-industrial	NA		NA	NA	NA	NA	NA	NA	NA
Agriculture	**NA**		**NA**	**NA**	**NA**	**NA**	**NA**	**NA**	**NA**
Agricultural Burning	NA		NA	NA	NA	NA	NA	NA	NA
Waste	**+**		**1**	**1**	**1**	**1**	**1**	**1**	**1**
Landfills	+		+	1	1	1	1	1	1
Wastewater Treatment	+		1	+	+	+	+	+	+
Miscellaneous Waste	+		+	+	+	+	+	+	+
Total	**20,936**		**16,892**	**16,682**	**17,091**	**17,189**	**16,013**	**14,802**	**14,324**

Source: (EPA 2003)
* Miscellaneous includes other combustion and fugitive dust categories.
+ Does not exceed 0.5 Gg
NA (Not Available)
Note: Totals may not sum due to independent rounding.

Table U-2: SO_2 Emissions from Electric Utilities (Gg)

Fuel Type	**1990**		**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**
Coal	13,807		10,526	11,105	11,443	11,312	10,594	9,614	9,031
Petroleum	580		375	418	466	691	525	428	476
Natural Gas	1		8	6	5	5	151	157	181
Misc. Internal Combustion	45		50	48	51	52	54	54	55
Other	NA		NA	4	4	110	44	78	73
Total	**14,432**		**10,959**	**11,581**	**11,970**	**12,170**	**11,368**	**10,331**	**9,817**

Source: (EPA 2003)
Note: Totals may not sum due to independent rounding.